Effects of nitrogen fertilization on pot-grown wheat photosynthate partitioning within intensively farmed soil determined by ^{13}C pulse-labeling

Zhaoan Sun[1], Shuxia Wu[2], Yiwen Zhang[3], Fanqiao Meng[1], Biao Zhu[4], and **Qing Chen[1]***

[1] Beijing Key Laboratory of Farmland Soil Pollution Prevention and Remediation, College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China
[2] Institute of Agricultural Resources and Regional Planning, China Academy of Agricultural Sciences, Beijing 100081, China
[3] Dryland-Technology Key Laboratory of Shandong Province, Qingdao Agricultural University, Qingdao, Shandong 266109, China
[4] Institute of Ecology, College of Urban and Environmental Sciences, and Key Laboratory for Earth Surface Processes of the Ministry of Education, Peking University, Beijing 100871, China

Abstract

Understanding rhizodeposited carbon (C) dynamics of winter wheat (*Triticum aestivum* L.) is important for improving soil fertility and increasing soil C stocks. However, the effects of nitrogen (N) fertilization on photosynthate C allocation to rhizodeposition of wheat grown in an intensively farmed alkaline soil remain elusive. In this study, pot-grown winter wheat under N fertilization of 250 kg N ha^{-1} was pulse-labeled with $^{13}CO_2$ at tillering, elongation, anthesis, and grain-filling stages. The ^{13}C in shoots, roots, soil organic carbon (SOC), and rhizosphere-respired CO_2 was measured 28 d after each ^{13}C labeling. The proportion of net-photosynthesized ^{13}C recovered (shoots + roots + soil + soil respired CO_2) in the shoots increased from 58–64% at the tillering to 86–91% at the grain-filling stage. Likewise, the proportion in the roots decreased from 21–28% to 2–3%, and that in the SOC pool increased from 1–2% to 6–7%. However, the ^{13}C respired CO_2 allocated to soil peaked (17–18%) at the elongation stage and decreased to 6–8% at the grain-filling stage. Over the entire growth season of wheat, N fertilization decreased the proportion of net photosynthate C translocated to the below-ground pool by about 20%, but increased the total amount of fixed photosynthate C, and therefore increased the below-ground photosynthate C input. We found that the chase period of about 4 weeks is sufficient to accurately monitor the recovery of ^{13}C after pulse labeling in a wheat–soil system. We conclude that N fertilization increased the deposition of photoassimilate C into SOC pools over the entire growth season of wheat compared to the control treatment.

Key words: ^{13}C pulse labeling / N fertilization / rhizodeposition / soil organic carbon / winter wheat

Accepted August 01, 2019

1 Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple crops in the world, covering approximately 220 million hectares (*FAO*, 2016). Rhizodeposition, *i.e.*, the release of photosynthesized carbon (C) from living roots into the soil, is one of the most important sources of soil organic C (SOC; *Kuzyakov* and *Domanski*, 2000; *Pausch* and *Kuzyakov*, 2018). However, the majority of photosynthesized C allocated below ground might be used by rhizosphere respiration, including root respiration and microbial respiration, utilizing rhizodeposited C from live roots (*Kuzyakov* and *Larionova*, 2005). Rhizodeposition approximately accounts for up to 30% of net plant-fixed C (*Jones* et al., 2009). *Sun* et al. (2018) also reported that the photosynthesized C input from wheat to the soil was 1.7 t C ha^{-1} in rhizodeposits only (18% of net wheat-fixed C) over the entire wheat growth season on the North China Plain. Approximately 40–50% (1.5–2.2 t C ha^{-1}) of net photosynthate C is allocated below ground for the total vegetative period in wheat and barley, *i.e.*, 19% to root biomass, 12% to rhizosphere respiration, and 5% to the soils (*Kuzyakov* and *Domanski*, 2000). However, below-ground C cycling remains poorly understood due to the complexity of root exudate composition, the high spatial heterogeneities in the rhizosphere, and a lack of appropriate approach to separate newly incorporated C derived from native SOC within the rhizosphere (*Kuzyakov* and *Domanski*, 2000; *Pausch* and *Kuzyakov*, 2018). Therefore, quantification of the allocation of photosynthesized C below ground is essential for further understanding of C cycling within the plant–soil system.

Plant factors, such as species and developmental stage, influence the distribution of photosynthesized C (*Kuzyakov* and *Domanski*, 2000; *Nguyen*, 2003; *Pausch* and *Kuzyakov*, 2018). *Mathew* et al. (2017) observed that grasses store up to 45% of the photosynthesized C in the roots, whereas

* Correspondence: Dr. Qing Chen; e-mail: qchen@cau.edu

